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JOURNAL

OF THE

AMERICAN WELDING SOCIETY

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American Welding Society

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AMERICAN WELDING SOCIETY

ESTABLISHED 1919

JOURNAL

Volume 4 January, 1925 Number 1

THE NEW YEAR

The members of the Society have been repeatedly urged to bring in at least one new member. A record is being kept of those members who fulfill their obligations in this respect. Public acknowledgment is made in the monthly Journal of the work of the individual members in securing new members by publishing a list of these new members and their sponsors. It is planned at the annual meeting to make still further acknowledgment to these loyal workers of the Society.

Every member of the Society knows someone who ought to be affiliated with it. Where a personal interview is possible such action is recommended but where this is impracticable, members are urged to send in the names of these prospective members to Society headquarters and the Membership Committee will do the rest. Full credit, however, will be given to those sending in the names if the Membership Committee is successful in its efforts.

Eminent leaders in the welding industry recognize that the extension of the use of welding in new fields must depend very largely upon the efforts and activities of the American Welding Society. It is easily seen that the efforts of the Society and its accomplishments are in direct proportion to the number of members. It matters little what connection an individual member may have with the welding industry. He profits by the prosperity of the industry. For example, the larger the industry the more prospects a welder has for advancement, the less likelihood there is for unemployment and the greater the opportunity for choosing the working conditions he likes best. The welding engineer also finds his services in greater demand and therefore gets a greater compensation. The user of welding profits by reduction in operating and maintenance costs and in many cases by having a better product. The manufacturing companies of welding supplies and equipment of course derive the direct benefit in increased sales.

Looking at it from another viewpoint, the Welding Society may be regarded as an insurance for the prosperity of the welding industry. It is the ever watchful guardian against adverse legislation. It is the recognized authority for reliable welding information to which the user of welding automatically turns. Research during the last few years has attained recognition as a source of revenue. Editorials are constantly appearing in all the technical trade papers urging each industry to take it up and share in its profits. Even in the older industries innumerable instances can be pointed out where a dollar spent wisely on research has yielded returns of several hundred per cent. Fortunately for the welding industry the American Welding Society has affiliated with it a research department known as the American Bureau of Welding whose pronouncements are recognized the world over.

In proportion to the efforts of the officers of the Society, your task is quite small but nevertheless very important, namely, that of securing one new member.

COMPRESSED GAS MANUFACTURERS' ASSOCIATION

The Compressed Gas Manufacturers' Association will hold its twelfth annual dinner at the Hotel Astor, New York, on January 26, 1925.

CHEMICAL SOCIETY TO FEATURE WELDING

The New Jersey Chemical Society will devote its January meeting to the subject of welding. The meeting will be held on January 12th at 8 o'clock in the Essex Club, Newark. Mr. F. E. Rogers of the Air Reduction Company will be the principal speaker.

DISCUSSION OF PAPERS

From time to time members have been requested to send in written discussions of various papers appearing in the *Journal*. In this way only can be obtained the greatest value of these papers. A single author, no matter how great his experience, can seldom cover all the existing information on a particular subject. Results of tests and experience can ofttimes be interpreted in several ways depending upon the viewpoint of the individual. In some instances your opinions might differ from those of the author. Unless these are set forth other members cannot know of these facts and erroneous or incomplete conclusions may be accepted as final.

WELDED RAIL JOINT ACTIVITIES

In the last issue of the *Journal* there was published a report of the sub-committee appointed to prepare a program comparing the variables which affect the quality of the seam-welded type of joint. A meeting of the committee is to be held in Washington on February 16th in connection with the mid-winter meeting of the American Electric Railway Association.

A great deal of work has been done by the Welded Rail Joint Committee during the past few months. The repeated impact testing machine designed and built by the committee is now pounding away continuously day and night in breaking up the various rail joint specimens by repeated blows of a magnitude equal to that ordinarily given by a car wheel in striking a bad joint. It is hoped that the Third Progress Report will be prepared before the meeting in February.

INDEX 1924 JOURNAL

Inserted in this issue every member of the Society will find a copy of the index for the 1924 volume of the *Journal*.

In this connection attention is called to the fact that the Society has on hand a few bound volumes for the years 1922, 1923 and 1924 which will be sold to members at $5.00 per copy.

BRIDGE COMPANY ENGINEERS INTERESTED IN WELDING

The January meeting of the American Bridge Engineering Club of New York, held at the Machinery Club on January 13, 1925, was devoted to welding. Mr. W. Spraragen, secretary of the American Bureau of Welding, gave an illustrated talk on the fundamentals of the gas, electric arc, resistance and thermit welding processes. A large number of slides were shown indicating a variety of applications in structural and tank work. The possibilities of welding were touched upon and this process was compared with riveting as a means of fabricating such structures. Mr. J. Edwards, Assistant Chief Engineer of the American Bridge Company, supplemented the talk by describing some tests made by the American Bridge Company and stated that in his opinion the Bridge Company should be using more welding.

SECTION ACTIVITIES

Boston

The December meeting was held on the 19th at Franklin Union Hall. Mr. S. W. Miller of Union Carbide and Carbon Research Laboratories presented a paper on "Welding of Cast Iron with Bronze." Welders were especially interested in determining just what kind of cast iron jobs could be done by this method without preheating. There was also presented at the meeting a demonstration of welding of cast iron with bronze by Mr. Brooklings of the General Electric Company. Specimens were welded and inspected by those present and broken to show the strength and soundness of welds. Mr. H. A. Woofter of the Thomson Electric Welding Company spoke on new and interesting applications of resistance welding.

The January meeting was held on the 16th at the Massachusetts Institute of Technology. The meeting was held in conjunction with the M. I. T. branch of the A. S. M. E. Prof. A. S. Kinsey of the Stevens Institute of Technology, Hoboken, N. J., was the main speaker of the evening. His subject was "Industrializing the Air." Mr. Van Alstyne, of the Air Reduction Sales Company, gave a very interesting talk on "Liquid Oxygen" and

a demonstration of its effects upon many articles of every day use. Mr. Van Alstyne's demonstration was followed by a moving picture illustrating the "Manufacture and Use of Oxy-acetylene Welding Gas and Equipment." The photographs of molten metal in the welding were particularly interesting. Following the moving picture, a demonstration was given of the "Gas Welding of Aluminum," by Mr. David H. Miller, of the Back Bay Welding Co., Brookline, Mass.

Chicago

At the December meeting, Mr. C. J. Holslag presented an interesting paper on the "Effect of the Flux Covered Electrode."

Philadelphia

The Philadelphia Section held its December meeting on the 15th. President Ewertz of the American Welding Society was the guest of the section and the meeting was well attended. Dr. Kelly of the Budd Manufacturing Company presented an interesting talk on the "Application of Welding on Automobile Bodies."

Northern New York

The January meeting of the section was held on the 12th. Mr. E. P. Jessop, Consulting Welding Engineer, gave a talk on the "Welding of Large Steel Tanks" and welding practice in general.

The general meeting was preceded by a dinner in the General Electric Company's restaurant. Capt. Jessop discussed the various types of joints and stated that the success of welding on any particular job depended considerably upon the welder himself and the practice employed in treating the job. He stated further that the average welder should be experienced in the following fundamentals of arc welding:

1. He must know how to control the heat, that is how to set the machine for a certain job.
2. He must know how to hold and be able to hold a steady arc.
3. He must be able to follow the line of weld exactly without variations.
4. He must know how to keep the metal clean to the best advantage.

Pittsburgh

The December meeting of the Pittsburgh section was held on the 19th. Mr. S. W. Mann of the H. Kleinhans Company presented a paper "Precision Welding of Steel and Cast Iron." Mr. Mann's paper was illustrated with lantern slides and sketches on the blackboard.

San Francisco

The January meeting of the San Francisco section was held on the 16th. The principal subject for discussion was the A. S. M. E. Code on the Welding of Unfired Pressure Vessels.

New York

The December meeting of the New York section was held on the 16th. Mr. F. C. Fyke, Engineer in charge of Testing Department, Standard Oil Company, Elizabeth, N. J., presented an illustrated paper on the "Application of Welding in the Oil Industry." Supplementing the presentation of the paper was a discussion by Hugh J. Boyle, welding supervisor, Tide Water Oil Company, Bayonne, N. J. Mr. Boyle painted a vivid picture of the hazards of the industry. He stated that the industry was depending upon welding and stressed the importance of making welds sound.

Testing welds, he said, is the bugbear of all welding. The greatest menace in the oil industries, he said, is fire, and he stated his conclusions as to the best method for insuring good welds about as follows: The quality of a weld depends largely on the welder and the supervisor. The work of any operator varies due to the condition of his health and due to the conditions that may exist at his home. If the supervisor is not constantly on the job bad welds are apt to go in. The great demand for operators has in the past and continues at present to a lesser extent to cause the employment of poor operators. Two grades of welding wire are used by the Tide Water Oil Company and the inspectors have learned how to tell whether the weld is good or not by watching the flow of the metal and the appearance of the slag. Welding must not be a contributary cause to the accidents which occur in oil refining plants. Eternal vigilance is the price of safety.

EMPLOYMENT SERVICE BULLETIN

Opportunities.—The Society is glad to learn of desirable opportunities from responsible sources, announcements of which will be published without charge in the BULLETIN.

Services Available.—Under this heading brief announcements (not more than seventy-five words in length) will be published without charge to members. Announcements will not be repeated except upon request received after an interval of three months; during this period, names and records will remain in the office reference files.

Note.—Copy for publication in the BULLETIN should reach the Society's Office not later than the thirtieth of the month if publication in the following issue is desired. *ALL REPLIES should be Addressed to the number Indicated in Each Case and Mailed to Society Headquarters.*

Positions Vacant

V-21. Welder wanted with at least five years' experience in job welding shop, principally automobile work; must be expert on cast iron and steel, expert on preheats, who has welded cylinders cracked internally, built up worn valve seats, etc. Knowledge of aluminum welding, chassis straightening, electric welding and boiler work, desirable but not necessary; salary to start, $50.00; location, New York; chance for foremanship. Write all details just where you worked and what you did for the past ten years in confidence.

V-22. Electric welder wanted in Norway with ship repair and cast iron experience. Full particulars, stating age, nationality, hourly rate and names of employers for past three years.

V-23. Assistant Executive. Opportunity for real live wire to connect with general repair welding and radiator works in fast growing city in north New Jersey. Established eleven years. To branch out owner needs reliable assistant executive. Capital not essential. Best location and most up-to-date equipment. Man of good personality and some experience can make unusual connection as active partner. Give particulars of past experience, age and monthly income expected.

V-24. Desires services of a young man who is familiar with welding shops in metropolitan district to sell welding rods and accessories on a commission basis with very good prospects for future development.

Services Available

A-31. Acetylene Welder. Has had 15 years of experience as a welder with good all around experience in the following lines: shipbuilding, boiler and tanks works, railroad, machine shop and steel mills. Have also worked during the past 8 years in same fields as electric welder. Am at present employed as an electric and acetylene welder. Have also acted as welding instructor in the British Navy. Am 35 years of age.

History, Manufacture and Applications of Manganese Steel*

J. H. HALL†

The invention of 12 per cent manganese steel dates back almost to the time of the discovery of the Bessemer Process. When Sir Henry Bessemer first attempted to make steel by blowing air through a molten bath of pig iron, he secured what was chemically steel, but what was physically an almost worthless product, as it could not be rolled or forged. In Norway and Sweden, however, the Bessemer process was a success and produced workable steel from the start; and to Gorannson, the Swede, and Mushet, the Englishman, belongs the credit for discovering that the reason the Swedish Bessemer steel was workable was the presence in the pig iron blown of a high percentage of manganese, some of which remained in the metal at the end of the process. Mushet demonstrated that the addition of manganese-bearing iron alloys to Bessemer steel at the end of the "blow" made the steel workable, and thus saved the Bessemer process from at least temporary failure.

Although later given the Bessemer medal, Mushet received so little recognition for this important contribution that he turned his attention to further utilization of manganese-iron alloys, and developed the first high speed steels for cutting tools, containing up to 2 or 2½ per cent manganese, which were an enormous improvement over the tool steels made previous to that time.

The Hadfields, in Sheffield, England, carried the utilization of manganese alloys a step further, and produced experimentally steels containing from 3 to 20 per cent manganese, that of the greatest permanent value being a steel containing from 11 to 13 per cent manganese, and the carbon, that nature provided should result from the use of standard 80 per cent ferromanganese, about 1.25 per cent. This carbon content has been found after many experiments to be the best for steels averaging 12 or 12.5 per cent manganese.

This 12 per cent manganese steel in the cast condition was quite hard, but brittle. As all steels known up to that time were softened and toughened by heating to a bright red heat and cooling slowly (annealing) and were made hard and brittle by sudden cooling from a bright red heat, efforts were made to render 12 per cent manganese steel tough by annealing it; and the more it was annealed the more brittle it became. One of their blacksmiths, we are told, on learning that every specimen he had prepared was still brittle, drew his last piece from the fire, tossed it into a tub of water, and gave up the attempt to toughen the steel. When the tub was cleaned out, weeks later, someone had the curiosity to test this piece, and to his intense surprise found that it was exceedingly

*Presented before the November meeting, Northern New York Section, A. W. S.
†Metallurgist, Taylor-Wharton Iron & Steel Co.

tough, and *still hard*. It was then, and still is, commercially unmachinable. Tool steels have been found that will turn it, and even thread it, but too slowly to be useful for regular production, so that all finishing to size has to be done with grinding wheels. It is our hope that eventually machining will be commercially practicable. Keyways and holes to be drilled and tapped are in most cases taken care of by casting in soft steel inserts, which do not harden in the heat treatment to which the castings are subjected.

The great toughness of the steel, fortunately, allows even severely warped castings to be straightened cold under powerful presses.

This was something entirely new to iron and steel metallurgy, a metal hard, but tough; and of course it promised to be exceedingly useful to resist severe wear of various kinds. The late Dr. Henry M. Howe, acting as the representative of Sir Robert Hadfield, brought the steel to the attention of American steel makers, and after several unsuccessful attempts to introduce it, arranged for its manufacture by the Taylor Iron Company of High Bridge, New Jersey. This concern has been continuously engaged in the manufacture of iron and steel in the hills of northern New Jersey since 1742, and for all those years the management has been in the hands of a single family, for which the Company is named. They have made iron or steel for every war in which this country has engaged. Only one other incorporated company still doing business on the North American continent is older than we—the Hudson Bay Company. The Taylor Company in the 1880's were manufacturers of axles and wheels for freight and passenger car service, both chilled iron wheels, and gray iron wheels with steel tires, and they were making the best wheels then obtainable. Competition from larger and more advantageously located shops was becoming so keen that the Taylors saw they must have a new and better product if they were to remain in business, and the new manganese steel promised to make an ideal car wheel. In 1891, therefore, they formed the Taylor Iron & Steel Company, built a small steel works, produced several hundred car wheels, and put them in service on the railroads of the country—to find, after a few years' trial, that for railroad cars, manganese steel wheels were an utter failure. In the thirty-two years that have passed since that first attempt, the company has grown until today we produce about 900 tons a month of manganese steel castings, averaging about 17 lb. in weight, but running from 3 ounces to 25,000 lb. We make only about 30 or 40 per cent of the total output of manganese steel castings in this country, so you see many uses have been found for it—and we are still finding new ones.

In order to understand why manganese steel car wheels were a failure, we must consider briefly the properties of manganese steel.

TISCO MANGANESE STEEL

C. Per Cent	Mn. Per Cent	Si. Per Cent	P. Per Cent	S. Per Cent
1 to 1.40	11.00 to 14.00	Max. 1.0	Max. 0.10	Max. 0.05

PHYSICAL PROPERTIES

Tensile Strength, Lb. per Sq. In.	Elastic Limit, Lb. per Sq. In.	Elongation in 2 In., Per Cent	Reduction of Area, Per Cent
70,000 to 100,000	30,000 to 40,000	15 to 20	15 to 25

Bend Test—A rough cast bar ½ in. x ¾ in. should bend cold on the flat side around a diameter of 1 in. to an angle of 180 deg. without breaking. Above are shown the average physical properties of heat treated cast manganese steel. The phosphorus you will note is rather high, the sulphur is very low, seldom if ever over 0.02 per cent though we show it here at 0.05 per cent. The tensile strength is high, yet we can today make stronger cast steels. The elastic limit is low, not much if any over 30,000 lb. per sq. in. This figure is obtained by the limit of proportionality, as there is no true yield point or drop of the beam, and published figures giving a yield point of 40,000 or 50,000 lb. per sq. in. are utterly misleading and worthless. The toughness as measured by extension, contraction of area and bend is high; the extension and contraction frequently run considerably higher than the figures we give here.

Measured by the ordinary static properties, manganese steel has a remarkable, but not unique, combination of strength and toughness; we produce other cast steels that exhibit better all-around static properties. It possesses, however, one property that is unique, and that is its hardness, and especially its power of hardening under cold-working. In the heat treated condition in which it is shipped, its hardness is high, about 180 to 200 Brinell, but nothing like as high as that of chilled iron or hardened steel; but when manganese steel is exposed to the sort of service that is probably best exemplified by the ordinary jaw stone crusher, in which the surface of the steel is indented and worked and kneaded by the pressure of the hard rock being crushed, the hardness of the outside layers of the steel, to a depth of about ¼ in., runs up very rapidly to 500, 550 and even 600 Brinell, the hardness of chilled iron. After a comparatively brief service, therefore, a manganese steel casting consists of a strong, tough backing, with an intensely hard surface, like a case hardened piece, or a piece that has been surface hardened by daubing the mold in which it is cast with a paste of oil and ferromanganese or other alloys. In a case hardened or surface hardened article, however, the hard layer is soon worn through in heavy abrasive service, exposing the soft metal below, which then wears away rapidly; while in the case of the manganese steel casting, the surface hardening is progressive and travels down as the piece wears. As fast as a new surface is exposed, it is automatically hardened, and thus the great resistance to wear is maintained throughout the life of the part.

We have found by careful tests carried on for several years in a small stone crusher, that the rate of wear for the first few tons of stone crushed, before the steel has become thoroughly surface-hardened, is considerably higher than the rate of wear for the greater part of the useful life of the casting. This is one confirma-

tion of our belief that this power of intense surface hardening, coupled with the great toughness of the casting as a whole, is chiefly responsible for the fact that in the *right kind* of abrasive service, 12 per cent manganese steel will outwear any metal with which it competes, 8, 10 or even 15 to 1.

Further confirmation of this opinion is found in the fact that in the sort of service where the wear is pure abrasion, with no working of the surface, manganese steel does not develop its maximum resistance to wear, and may give no better account of itself than other ferrous metals. Manganese steel fronts and teeth for steam shovels, for instance, last for months when handling hard blasted rock; but when digging soft shales or glacial clays containing large amounts of finely divided quartz or other hard minerals, the abrasive action, in the absence of any possible cold working sometimes wears away the teeth to the roots in a week, or even in five days. We have had some angry customers when steam shovels on which manganese steel had been lasting for months in rock work were transferred to soft ground, "easy digging," and the teeth wore out in a week.

When there is very severe cold working of the surface, and little abrasion, trouble is sometimes encountered from another source—the flowing or peaning of the surface of the steel; for of course cold working means the repeated indenting of the surface and the metal that is displaced must go somewhere. Castings sometimes develop a pronounced overhang at the edges, and even increase measurably in over-all dimensions, from this cause, which may lead to trouble where two castings meet, or at the ends of a long casting. This difficulty can in almost every case be taken care of in the design of the job, but in the days before we understood this as well as we now do, we occasionally had cases where the linings of ball mills either buckled up and came loose, or pushed the heads out of the mills from actual spreading of the plates; and there were other cases where similar difficulties were encountered.

The failure then of railroad car wheels of manganese steel was due to both of these sources of trouble just described. The resistance of the treads of the wheels to wear was excellent, but the metal flowed and peaned to such an extent that the inside of the treads developed overhanging fins that had to be ground off at intervals; and the flange wear as the trains rounded a curve with the flanges of the wheels grinding against the sides of the rail heads was quite rapid, as the wear at this point was almost pure abrasion with little or no cold working to harden the steel.

In striking contrast to the service of wheels, special track work parts such as frogs, crossings, switches, etc., are one of the largest and most important applications of manganese steel. Of course in this application side wear is generally slight, and the peaning is never sufficient to cause trouble.

Manganese steel has another weakness that is directly due to the very property that gives it its remarkable power of resisting

the right kind of wear, and that is a low resistance to heavy, repeated stresses approaching or slightly exceeding its rather low elastic limit; in other words, it does not resist heavy fatigue stresses as well as some other steels. The reason for this is that when the outside fibers are slightly stretched under the stresses imposed upon them, and these stresses are regularly repeated, the steel hardens and becomes brittle from the cold working, and eventually cracks. Once such a crack is started, it usually spreads rapidly and the piece fails. Laboratory tests have shown us that manganese steel will not resist such service as long as other heat treated cast steels we make, and in service we have encountered instances where castings have failed by cracking in perfectly sound, tough metal, before they had worn an appreciable amount. This difficulty can in almost all cases be taken care of in design, but in some few instances where the machine is so constructed that space is not available for stiffer and heavier castings, the trouble is insuperable, and other steels must be used, which do not resist wear nearly as well as does manganese steel, but are stronger against fatigue failure.

Another property in which manganese steel is almost unique is that like the steels containing 20 per cent nickel or over, it is non-magnetic, hardly attracting the magnet. In the last few years the General Electric Company and other companies have used manganese steel in places where a strong, tough, non-magnetic metal is required, and we hope to see these applications much extended in the next few years. We have given figures on this and other properties of 12 per cent manganese steel in a paper before the A. S. T. M. in June, 1924, which will be published in the proceedings of that Society.

MANUFACTURE

We make our steel in the first instance in a 3 ton bottom blown Bessemer converter, mixing in a ladle about 5 parts of low carbon metal from the converter and about 1 part of melted 80 per cent ferromanganese.

LADLE MIXTURE

Material	Weight	Per Cent C.	Lbs. C.	Per Cent Mn.	Lbs. Mn.
Melted Bessemer blown metal	5,400	0.15	8.1	0.40	21.6
Melted Ferro Manganese	1,150	6.5	74.75	80.0	920.0
Manganese Steel	6,550	1.26	82.85	14.37	941.6

The above table shows the ferromanganese contains enough carbon to bring the carbon of the steel to about 1.25 per cent. The manganese you will note, figures to nearly 14.5 per cent. Our Bessemer blown metal contains about 0.40 per cent manganese, sometimes even 0.80 per cent or even 1 per cent. That is because we are using the Swedish practice that Mushet investigated, and charge our converter with metal containing over 2 per cent manganese, and about 1.25 per cent silicon. This metal blows faster and hotter than lower manganese mixtures, and we believe that

the residual manganese in the blown metal protects the steel from over-oxidation and gives us better metal than if we blew iron low in manganese.

The silicon runs about 0.60 per cent to 0.80 per cent, most of it coming from the ferromanganese, and the phosphorus averages 0.80 to 0.90 per cent, of which the greater proportion is contained in the ferromanganese also. We have investigated the effect of phosphorus in 12 per cent manganese steel, and find traces of its harmful effect at 0.125 per cent, and marked signs of trouble at 0.15 per cent. We set our top limit at 0.1 per cent, therefore, and believe we are well below the danger point.

We also make manganese steel, out of manganese steel scrap, in a 3 ton basic Heroult electric furnace. The electric furnace, when properly operated, makes better carbon, or nickel or nickel chrome steel, than any other steel making process, and when we installed the electric process, in 1917, we hoped that the same thing would be true of 12 per cent manganese steel. After 7 years' operation, however, and after making thousands of tests of every kind, we find that there is nothing to choose between the converter manganese and the electric furnace product from the point of view of quality; one is no better than the other. There must be reasons for this, and we believe we have found three at least of these reasons.

In the first place, the high quality of carbon steel made in the electric furnace is due to the very low sulphur content of well made basic electric furnace steel. But this is of no interest to the maker of 12 per cent manganese steel, because part of the manganese of the 80 per cent ferromanganese unites in the ladle with the sulphur of the Bessemer metal and the resulting sulphide of manganese floats out of the steel; as a result, manganese steel never contains over 0.02 per cent S. which is as low as the sulphur of the best electric furnace steel.

Secondly, electric steel is of superior quality because it can be made very low in phosphorus. This is not true, however, of electric furnace manganese steel, because most of the phosphorus comes from the ferromanganese, and after the manganese is added to the steel in the ladle, phosphorus can not be eliminated without almost total loss of the manganese. For this reason electric furnace manganese steel is very little, if any, lower in phosphorus than the converter-made product.

In the third place, the electric furnace makes very high grades of steel because it makes possible a more complete deoxidation of the steel than can be secured in any other process. However, when we mix Bessemer metal and ferromanganese in a ladle, we add nearly 14.5 per cent manganese, and we get on an average 12 to 13 per cent. The 1½ to 2½ per cent manganese that is lost is largely used up in deoxidizing the Bessemer metal, and we believe that the resulting manganese steel is as thoroughly deoxidized as

is the electric furnace product, so that it is equal to it in quality in every way.

We retain the electric furnace because it enables us to remelt our foundry scrap, defective castings and worn out castings returned from service, without loss of the manganese contained which is not possible by any other process; the steel thus made is of the best quality, and at usual prices of raw materials, recovery of the manganese results in a considerable saving in dollars and cents.

The heat treatment which was indicated in the first part of this paper, heating the castings to 1060 deg. C. (about 1940 deg. Fahr.) and quenching them in a large tank of cold water (and that's all) is a very drastic treatment. The steel has a rather high coefficient of expansion and a low thermal conductivity, so that in large and complicated castings there is a great difference in cooling rate at different parts of the piece, not only in cooling off in the water, but in cooling in the molds and in heating up for treatment as well. As a result, heavy stresses are set up in the castings, which can not be relieved by the usual practice of re-heating to a lower temperature, because heating the quenched steel to a temperature high enough to relieve stress appreciably makes the steel exceedingly brittle, due to metallographic changes. The design of manganese steel castings, therefore, has to be very carefully considered, and we cannot too strongly urge engineers to get the advice of the makers of manganese steel castings before attempting to design complicated castings of this metal. If they do not, they will be certain to send in many patterns that simply cannot be made in manganese steel. Our problem is far more difficult than that of the ordinary steel foundryman, and we are obliged to employ a large drawing room staff, quite a number of whom spend a large part of their time redesigning castings so that we can execute orders for them.

Fusion welding of manganese steel for strength is so far an impossibility, for two reasons. The first is that reheating the toughened steel to about 450 deg. C. makes the metal brittle, regardless of the rate at which the steel is cooled from this temperature. Surrounding every weld, therefore, is a zone of very brittle steel. By heating the whole casting to 1060 deg. C. and quenching it in water, this brittleness can be eliminated.

There is, however, a second damage done to the steel in welding, and that is true burning of the steel that has been heated above the solidus. We have found that reheating manganese steel to 1200 deg. C., produces partial melting and true burning, exactly as would be true of any other high carbon steel; and although after a retreatment at 1060 deg. C. the steel looks under the microscope as though its toughness were restored, actually it is not. For this reason, manganese steel welds usually fail in the manganese steel close to the metal welded in, and the strength of such welded pieces is but a fraction of that of the unwelded article. I have here a number of welds of manganese steel made with 33 per cent nickel steel

welding rod, bent to incipient failure, sectioned, polished and etched. The nickel steel was used because it does not tarnish with acids as manganese steel does, so that the line of failure is clearly seen. You will note on examination of these specimens that a true weld has been secured, but failure of the manganese steel close to the weld metal has taken place at a very low angle of bend. The weakness of this zone of burned manganese steel is apparently due to inclusions of oxide at the junctions between the crystals of the steel. Mr. S. W. Miller of your Society has done excellent work in attempting to solve this difficult problem, and he is to cooperate with us in further efforts. We hope we shall eventually succeed in making really strong welds in manganese steel, but are not confident of success.

Of course when the part is not to be subjected to severe stresses, a well made weld in manganese steel will serve its purpose, but we want to emphasize particularly that the strength of the welded piece is below that of normal manganese steel.

An All-Welded Barge

W. L. WARNER†

The application of electric arc welding to the construction of ships has been receiving some attention from boat builders ever since the World War, but it has remained for the Saxe Providence Boiler Works of Providence, R. I., to build and launch the first all-electrically arc welded boat in America. This boat will be used by the Pennsylvania Petroleum Products Company for transporting oil between Fall River, Mass., Providence, and New Bedford.

The barge is 76 ft. long, 21 ft. wide, and the deck is 11 ft. above the keel. Work was started in May, 1924, and the completed barge was launched during the second week of December with appropriate ceremonies. Electric arc welding was used throughout the entire barge, no pins or rivets being used. The largest number of men used at any one time was six, and Mr. Saxe estimates that, had the barge been constructed by the ordinary riveting method, a force of 18 men would have been required.

Fig. 1 shows the construction of the bottom of the barge. The welders were working on the keelsons when this photograph was taken. The hull of the barge is constructed of 3/16 in. plates joined by two fillet lap welds as shown in Fig. 2A. The angle-iron ribs shown in Fig. 1 are 3 in. x 3 in. x ¼ in. angles, spaced 22 in. apart, and are tack welded on both the toe and heel side by four-inch tack welds, 8 in. apart.

The barge is built around two cylindrical tanks of riveted-welded construction, purchased from the Adamson Tank Co. Each tank is 8 ft. in diameter and 67 ft. long and have a capacity of

†Industrial Engineering Dept., General Electric Co., Schenectady.

26,000 gallons of oil. The barge and tanks have a total weight of 70 tons. Each tank rests throughout its entire length on a keelson 16 in. in depth running the length of the barge. In addition to

Fig. 1—Completing the bottom of the hull for the all welded barge

this keelson, there are five double-saddle foundations acting as cradles in which the tanks rest. These cradles can be seen in Fig. 1.

The barge is divided into four compartments by three watertight bulkheads shown in Fig. 3. In. Fig. 4b is shown the manner

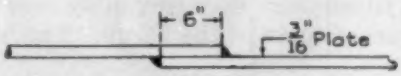

Fig. 2A—Details of the construction of the all welded barge

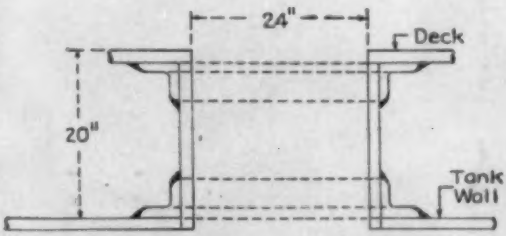

Fig. 2B—Details of the construction of the all welded barge

of attaching each of the bulkheads to the shell of each tank. Oil will be carried in the two middle sections of the hull around the outside of the tanks. The end sections will be reserved as bulkheads containing air for purposes of buoyancy (Fig. 6).

There are four manhole chambers 24 in. in diameter, running

through the deck from each of the tanks as shown in Fig. 2B. An angle ring collar is welded to the deck as a support for the manhole casing. These manhole chambers allow for expansion of the oil and also afford easy entry to the tanks for purposes of cleaning.

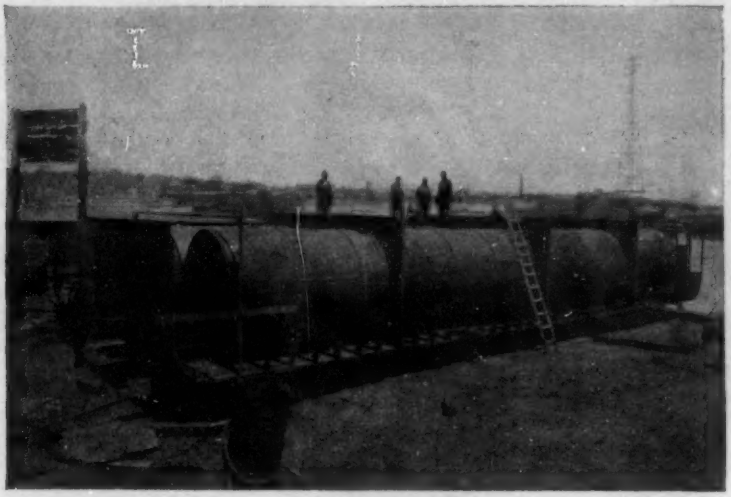

Fig. 3—All welded barge with tanks and cross bulkheads in place

The deck beams are 2 in. x 2 in. x ¼ in. angles and are braced to the tanks with No. 10 gage plates. All seams between the deck plates are welded watertight, preventing any washing of water into the hull. The hull framework may be plainly seen in Fig. 5.

Fig. 6 shows a general plan of the barge. The bulkhead (1) may

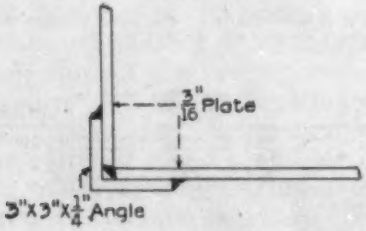

Fig. 4A—Details of the joint at the lower corner of the hull

be noted in Fig. 5 at the end of the tank nearest the camera. Keelson (2) may be seen under the tank in Fig. 5. Keelson (3) which may be noted in Fig. 1, is 27 in. in depth and extends only through the two end compartments. In the two middle compartments there is a longitudinal bulkhead (4) extending from the bottom of the barge to the deck. This bulkhead acts as another keelson. Sections of the barge at various points are shown in Fig. 7.

A wooden bumper extends around the barge as indicated in Fig. 7. This bumper is a 6 in. x 8 in. pine timber bolted to the hull and supported at the top and bottom by 3 in. x 3 in. angles welded to the hull plates. Fig. 8 shows the laying of the side plates.

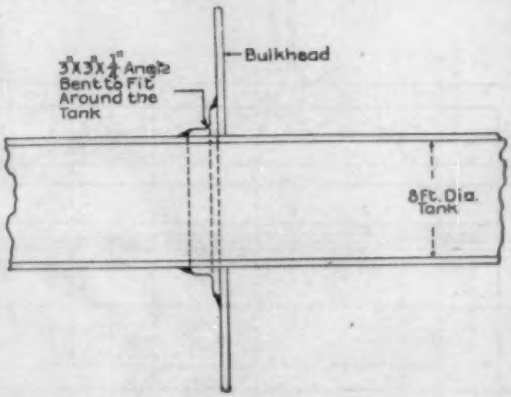

Fig. 4B—Details of construction of the all welded barge

There is a deck railing extending around the barge as shown in Fig. 7. There is a deck house at one end of the barge consisting of two rooms for one occupant, whose duty is to attend to hawsers,

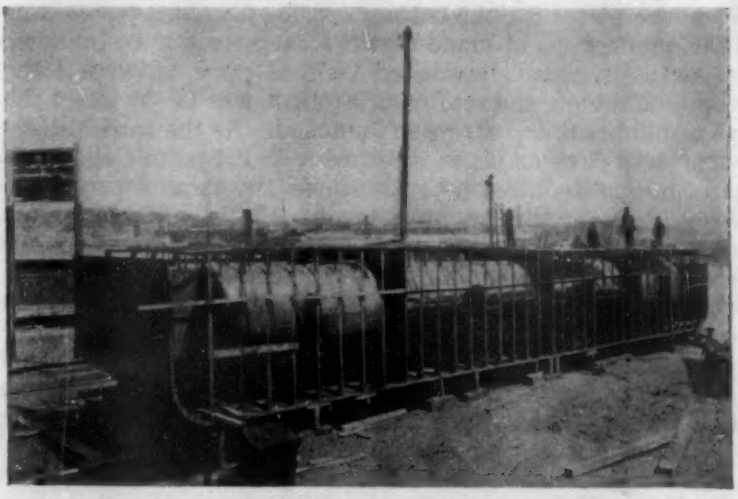

Fig. 5—All welded barge with hull and deck framework in place

tow-lines and various other details of operation. The towing bitts are located two at each end of the barge and are fastened to the tanks, thus avoiding any concentrated towing strain on the hull.

The Saxe Providence Boiler Works, which built the barge has been engaged in the construction and repair of tanks for 14 years.

In this work Mr. Saxe is using electric arc welding almost exclusively. His welding equipment consists of three stationary motor generator welding sets and one gas engine welding set.

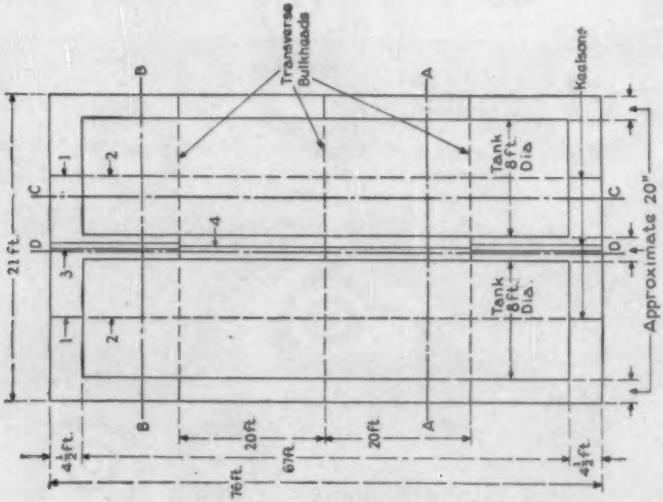

Fig. 6—General plan of all welded barge

When the plates for the bottom of the all-welded barge were laid and the announcement made that the barge was to be built without rivets or bolts, many interested visitors came to inspect the job. The opinion among the seafaring element was to the effect that the barge would break in two when launched. As the work progressed, however, and further visits were made, this attitude changed until skepticism was replaced by enthusiasm. A keen interest has been expressed unofficially in government circles and Captain John Brooks, government hull inspector, states that this is the nearest approach to a non-sinkable ship he has ever seen.

From Fig. 1 it will be noticed that the barge was constructed at some elevation above the surface of the water. For this reason it was necessary to build inclined launching ways from the end of the skids to the surface of the water. Then the shoreward end of the skids were jacked up until the skids were in line with the ways, after which the blocking was knocked out and the barge slid into the water. The barge was launched on Saturday morning, December 13, 1924. The completed barge is shown in Fig. 9.

The building and launching of this barge shows some very interesting things about electric arc welding and arouses great interest in a one-piece ship.

First, the flexibility of the process offers opportunity for simplified construction and for making easy changes or alterations, unforeseen when the plans were made. For instance, the attachment

of the bulkheads to the tanks could have been made only at considerable cost and delay if riveted construction had been used. In fact, this would have been very difficult to accomplish satisfactorily with riveting. Again, for riveted construction, detailed drawings

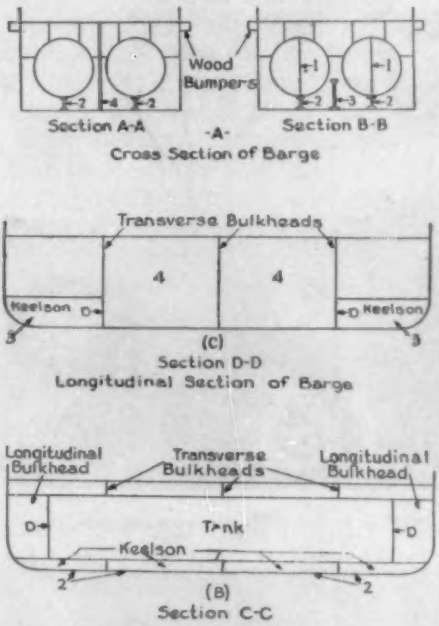

Fig. 7—Sketch of all welded barge at places indicated in Fig. 6

showing rivet holes and connections would have been necessary. In the present case, no drawings were necessary and none was used. The plates and other parts were cut to fit with the oxy-acetylene torch on the job and welded in place. Any changes or alterations were made without delay or extra expense.

Second, the cost of construction is much less than when riveting is used, as may be noted from the following comparison:

Riveting		Welding	
Labor—18 men at an average of 80c. per hour for a 9-hr. day	$129.60	Labor — 3 electric welders at 90c. per hour 9-hr. day	$24.30
Rivets—one keg per day	7.00	1 gas cutter and 2 fitting up men at 90c. per hour, 9-hr. day	24.30
Air compressor running cost.	5.00	Oxygen—500 cu. ft. at 2c. per ft.	10.00
		Acetylene—50 ft. at 4c. per ft.	2.00
		Gas—electric welder running cost	5.00
		Power for 2 motor-generator welders—50 kw. hr. per day at $0.0746	3.73
Totals	$141.60		$69.33

It should be noted that fuel and labor charges for rivet heating, laying out and punching are partly balanced by the cost of electrode material consumed in the welding process. About 2¾ tons of electrodes 5/32 in. in diameter and 14 in. long were consumed in

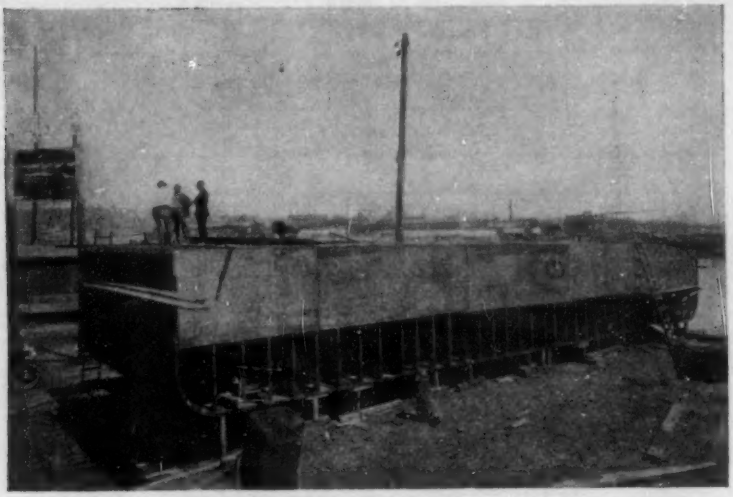

Fig. 8—All welded barge with one row of side plates assembled

Fig. 9—The completed barge

building this boat. Of this amount it may be estimated that approximately 2 tons of metal are actually in the welds. Thus, it will be seen that, excluding the costs common to both processes, two electrically welded vessels could have been built for the price of one riveted boat.

Third, the joints throughout are water tight when made and the caulking of rivets is eliminated.

Fourth, the completed structure is one solid piece and there is no opportunity for the loosening of seams, since the working of the plates is impossible.

However, it may be insisted that a riveted barge could have been built in fewer actual working days than the number required to build this one, which was started during the second week of May, 1924. The answer to this is that about four weeks were lost because of bad weather, which makes the actual time of construction about five months from the start to the launching. Also, this period includes some extra time which was required to build the deck-house and add the deck railing, chests, a hanger for a life boat, and flagpole not included in the original plans. Then, again, it must not be forgotten that the building of this barge was a new venture for Mr. Saxe and he surely deserves much commendation for his faith in the welding process and its satisfactory application to ship construction.

The Use of Fluxes in Electric Arc Welding*

C. J. HOLSLAG†

It is a well-known fact that high temperatures are invariably favorable to a chemical reaction. Consequently the temperature generated by the electric arc, which will melt refractory metals with ease in an instant, and is the highest temperature that can be produced, would naturally greatly encourage any tendency toward a chemical reaction. The first reaction is the universal chemical reaction—oxidation, and it will occur readily if the melting process takes place in air or anywhere in the presence of oxygen. There are many other chemical and physical changes due to the arc such as compounds of carbon and nitrogen furthered by the high temperature of the arc which are undesirable in the completed deposit. The problem, therefore, that confronts the welding operation, or any process in which the melting of metal is concerned, is to prevent as far as possible the partial combination of the molten metal with oxygen and nitrogen; in other words, to avoid the formation of metallic oxides and nitrides. These compounds are, in general, very detrimental to the success of welding or casting, because they form inert, impervious and brittle masses which are liable to become entrapped in the weld, creating weak and imperfect sections. Therefore, any agent which will act to prevent their formation in the melting and welding of metal is highly desirable. The greatest of these aids is found in the use of the various kinds of fluxes.

The chief problem is, primarily, to shield the molten metal as far as possible from contact with the air, and then to dispose of what-

*Presented at the December, 1924, meeting of the Chicago Section, A. W. S.
†Chief Engineer, Electric Arc Cutting & Welding Co.

ever oxides or nitrides have unavoidably formed. If the proper fluxes are chosen, both these conditions may be thoroughly realized. If it is possible to surround the active weld with an inert mass that will melt at the temperature of the arc but will not combine with the air, the molten metal will then be prevented from coming in contact with the air, and oxidation be greatly reduced. This is actually the condition realized in the use of the slag-coated electrode, which has a coating of such thickness and quantity as to melt at a steady rate with the melting of the electrode tip, and forms an envelope at all times about the arc and the molten puddle. A coating such as this may be of slag, asbestos, or various silicates, in short, any material that may be used as a coating, and will not combine with oxygen.

Besides this type of inert coating, the electrode may be coated with fluxes which are chemically active in a favorable way. These are valuable for other duties besides the all-important one of preventing oxides and oxidation; they may be chosen to combine with and eliminate various undesirable elements in the welded metal itself; they may be effective in producing any desirable chemical composition in the deposited metal, or they may, as in soldering, act to clean the welding surfaces from dirt, grease or oxide. All these actions, are, of course, favored by the heat of the arc, and may be combined in one coating of flux. It is well known, when welding with bare wire of any ferrous composition whatever, that the resultant weld is composed of pure iron, because the high temperature of the arc drives off the other ingredients as gases. It is the function of the flux to prevent this state of affairs, and it does prevent it in a most effective way. As a matter of fact, modern developments in flux coatings have made it possible to lay down deposited metal of a *predetermined composition*, so that it is now possible to duplicate in the weld such metals as manganese steel, high-carbon steel, and other steels of very special qualities impossible to deposit with the bare wire electrode, no matter what its composition.

The quality obtainable with the use of the flux coated electrodes makes them more economical than those of bare wire. With the flux coated electrode, it is possible to duplicate all the physical properties of cast steel—ductility, elongation, tensile strength, alternating stress, etc. In fact, tests made by the Interborough Lines of New York City in 1918 before a committee composed of Interborough engineers, engineers of the Public Service Commission, and of the State of New York, resulted in the verdict that such an electrode possessed all the properties of good cast steel.

Likewise, in August, 1919, the Wirt-Jones tests showed that the properties of ductility and elongation were increased as a result of the cold-bend test, and at no sacrifice to strength, because in each case the test piece broke outside the weld.

Fluxes are also useful in ridding the weld of such undesirable impurities as sulphur and phosphorus, both of which tend to pro-

duce a hard, brittle mass of metal in a weld. This type of flux is usually composed largely of silicates, which readily combine with impurities and which, in addition, possess the advantage of forming the already-mentioned inert envelope about the arc.

In cast iron welding, a great modern development of the art, the use of the flux is almost indispensable. This type of flux either unites with the excess of carbon in the cast iron, or tends to keep the hard carbon-iron compounds from forming. It is composed of a compound rich in carbon, such as lime or other carbonate, which becomes active under the heat of the arc and resupplies the free carbon which tends to keep the weld soft. In addition to this, the flux should contain nickel, silicon, manganese, or other compounds which prevent oxidation, tend to keep the weld molten, and bring about other desirable results. The flux coated steel electrode is of great assistance in all studding work, and any other work of a kind in which special conditions do not have to be met. A specially developed flux makes possible the use of an electrode actually made of cast iron. This flux provides for a quieting reagent, rapid floating of dross to the surface, absorption of oxygen or nitrogen, and a protection against rapid surface cooling. This is the highest development of which a flux is capable at present, and makes possible a weld with the iron electrode which possesses all the qualities of the original cast iron. Moreover, the use of this flux requires no special preparation, and a rod with this coating is deposited with only the usual care required in welding.

It will be seen from this that for a multitude of uses there is no satisfactory substitute for the flux-covered electrode in arc welding. The flux coating not only aids in many special ways, but actually lowers the cost of the weld by its capabilities of greater speed of deposition and surer production of consistently desirable results. Of course, a skilled operator with a bare wire electrode may hold a close arc so as to cut the oxidation down as much as possible, and produce good results, but for general use in the hands of the average operator, the fluxed electrode is best, not only because it is capable of greatly improving the weld, but because it is easier to run, and allows the operator's attention to be directed on the work instead of on the electrode. There are other ways of adding flux to a weld than by means of a coating on the electrode, but these methods are mostly ineffective. Granting that flux is beneficial at all, then surely the most logical way of introducing it into the weld is at a calculated rate through a coating on the electrode, not by throwing it into the weld at intervals, or by dipping the electrode tip into a keg every now and then. It is maintained that puddling the molten weld with an iron rod is effective in floating some of the oxide to the surface, but this is at best a puttering process, and cannot compare with the quick, sure action of a good flux.

Flux coated wire is speedier and more efficient than bare wire on three counts. First, it requires less brushing, preparation and

interrupting of the actual welding operation; second, the voltage across the fluxed arc is higher than across the bare rod, and the amount of work done is directly proportional to the amount of energy liberated at the arc. Hence, on the same current, welding is proportionately faster with a higher voltage; third, there is less spatter and unnecessary oxidation with the fluxed electrode because the arc is concentrated or focussed like a stream coming from a nozzle, whereas, with the unfluxed electrode, the arc shows a tendency to widen, much in the same manner as water coming from a hose without a nozzle.

Every metal founder knows that without the proper fluxes he would be helpless, and could not produce a perfect casting. The electric arc welding process consists of casting metal on a small and highly concentrated scale, and so is benefited by the use of fluxes to an even greater extent. On some electrodes, the flux coating is thick and heavy, on others thin; still others are half-coated, so that the arc will be encouraged ahead when the electrode is used with the bare side advancing. The added advantage of this last type lies in the protection given to the already-welded metal by the curtain of flux which drops down behind the arc and protects it from oxidation. A very heavy flux coating has not been found necessary for ordinary welding purposes, although for cutting, where an excess of oxidation is desirable, the coating may be in excess to assist the reaction. The ordinary medium-fluxed wire, however, is most effective in producing welds of consistent excellence.

Spot Welding Equipment*

J. A. OSBORNE†

We have a number of spot welding equipments at our shops, the majority of which are used with thin gage metal in the passenger departments. Their capacity is about 3/16 in. steel. I do not believe you are particularly interested in these small welders.

I have done considerable experimenting in the welding of heavier sections and while the spot welded freight car which we built a number of years ago has operated to date successfully, our company has been slow to adopt this process for the heavier sections, due to the difficulties of applying the process to the general manufacture of freight cars and also to the railroads hesitating to approve so radical a departure from the old standards of building.

I am sure that the time is not far distant when this process will be accepted and approved for all kinds of heavy structural work.

Complying with your request, I beg to advise that in one of our experiments I contemplated the welding of standard shapes and

*From information furnished the American Bureau of Welding.
†Chief Electrical Engineer, American Car & Foundry Co.

sheets. The total thickness of metal welded did not exceed 1½ in. We designed and built the transformer and other parts of the machine. The transformer had a capacity of 70 k.v.a. and was designed for 440 volts, 60 cycle, single-phase, provided with percentage taps, in order to give the necessary adjustment of secondary current. It was necessary to design this machine having a maximum open circuit secondary voltage of 25. This voltage, of course, could be varied to suit different thicknesses of metal.

The current required for ¾ in. diameter welds through 3½ in. pieces was approximately 30,000 amperes and it required about 40 seconds to complete the weld. The pressure was applied by means of an air cylinder and was approximately 8000 pounds. The current was applied by means of a remote control switch and released in the same manner.

I do not have the chemical analysis of the metals but the material used was standard structural steel having the usual proportion of carbon, etc.

It was developed that the surface of the material made no difference, that is, metal having a slight scale or oxide was found to weld better than material which had been cleaned or sand blasted and the proportion of good welds were greater in the former case. The welding current has a tendency to volatilize and expel the impurities.

I have tested a great number of samples of spot welding in comparison to identical riveted joints and with equal cross section of welds and rivets. The spot welds show from 50 to 85 per cent more strength than the rivets tested in the line of shear.

It was found that a welded structure was more rigid and the deflection under load was much less. I have been working on this subject for some time in an endeavor to adapt the process to the heavy construction of car work. I am thoroughly convinced that it is not only more economical but cheaper and more efficient.

Welding as Applied to the Oil Industry*

Welding can be classified as becoming one of the many present day necessities in the oil industry. Its application in some form or other can be found from the time the oil first comes out of the ground until it is ready for marketing. You will appreciate that any paper covering all of its applications can only be a general summary, for many of the applications are of such magnitude as to warrant individual papers being prepared on them alone.

The simplest definition of welding is given as the permanent union of two sections of metal while softened by heat. When weld-

*Presented before the December, 1924, Meeting of the New York Section, A. W. S.
†Engineer, Testing Dept., Standard Oil Co. of N. J.

ing is spoken of in the oil industry, it is this general conception that one has in mind, rather than pertaining to any of the particular classes of welding. Sometimes when spoken of, it is thought of as the particular process that may be employed.

The writer realizes that all of the different types of welding have their particular fields, some overlapping more than others. While the adoption of any one particular kind over another is always advisable, due to the nature of the work and existing conditions, the intent of this paper is to cover the application of all the different types of welding purely from a standpoint of a consumer.

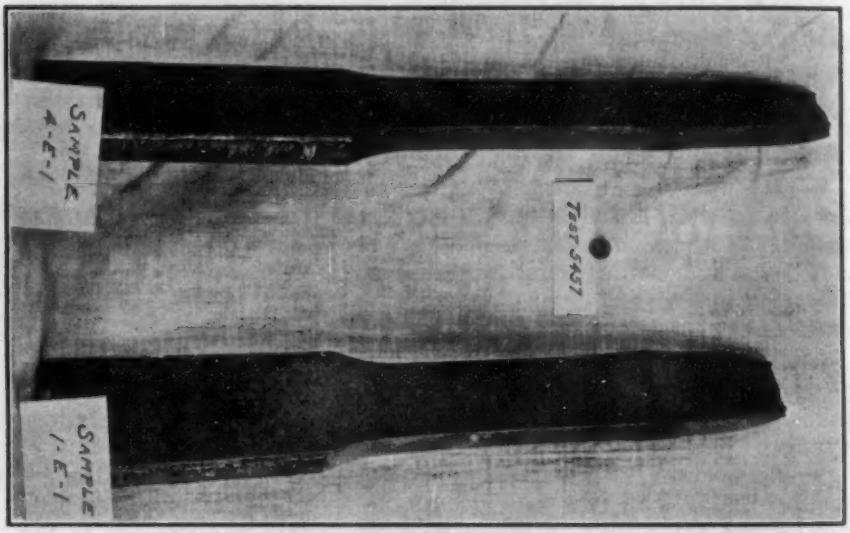

Fig. 1—Sample of tensile test specimens showing fracture outside of weld

Any reference which may be made later regarding the applications of welding, in any form or other, should be taken as the practice of the industry as a whole, and not that of any one particular company.

Before taking up the different applications of welding with reference to the oil industry, I wish to touch briefly upon some of the points that are of paramount importance, in order to assure ourselves of obtaining a good weld, regardless of the industry involved.

Probably the one thing that is retarding the art of fusion welding more than any one other is the lack of, or inability to apply, any practical test to the finished work that will be indicative of a sound weld and enable one to pick out bad welds after once made. While the surface appearance, if closely studied and checked with the test results, does give an indication of the quality, in a single bead weld, this check is of very little value in the case of heavier welds. X-Ray examinations of welds have been made, with a view of arriving at some means of detecting defective welds, but the development that

has been made to date shows that there is very little practical application of this method. The most promising method, in the testing of welds, is the magnetic process. However, due to the sensitiveness of this apparatus, it is doubtful whether this method will be practical in shops where heavy work is being carried on and vibrations are excessive.

As already mentioned, the lack of suitable means for the practical testing of welds, so as to indicate or show the engineer when he has a sound weld, results in the much used saying, which we are all familiar with, that is, that the weld is no better than the operator. This alone is causing the engineer to hesitate in advocating a broader application of welding, particularly in high temperature and pressure work, in spite of the rapid strides made by the art

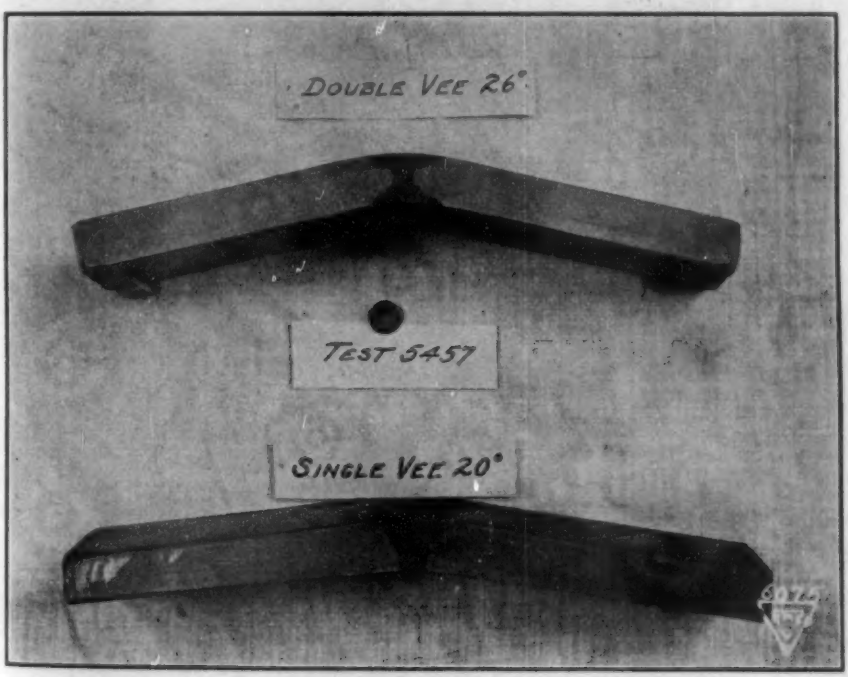

Fig. 2—Bend specimens showing nature of weld at maximum bend

during the last few years. This problem is one that should be given attention by this Society and is of such importance as to warrant extensive research work being made. The question of design can be easily taken care of once we have means of knowing what we have to design with.

The human element, upon which depends to a large extent, the quality of the weld, must be carefully studied if the best results are to be obtained. The mere hiring of a man who says he is a welder should mean very little in the welding shop until he has demonstrated to the satisfaction of his foreman that he is capable and

can be trusted on any class of work. Gas welders and electric welders are each in a class of their own and to obtain the best results they should not be interchanged on both classes of work. Shop conditions may be such, however, that, while desirable, this practice cannot be always carried out.

In the selection of men for the training as welders, they should possess certain qualifications which should prove valuable assets to them in helping them become successful welders. They should be enthusiastic about the subject and have had enough mechanical ex-

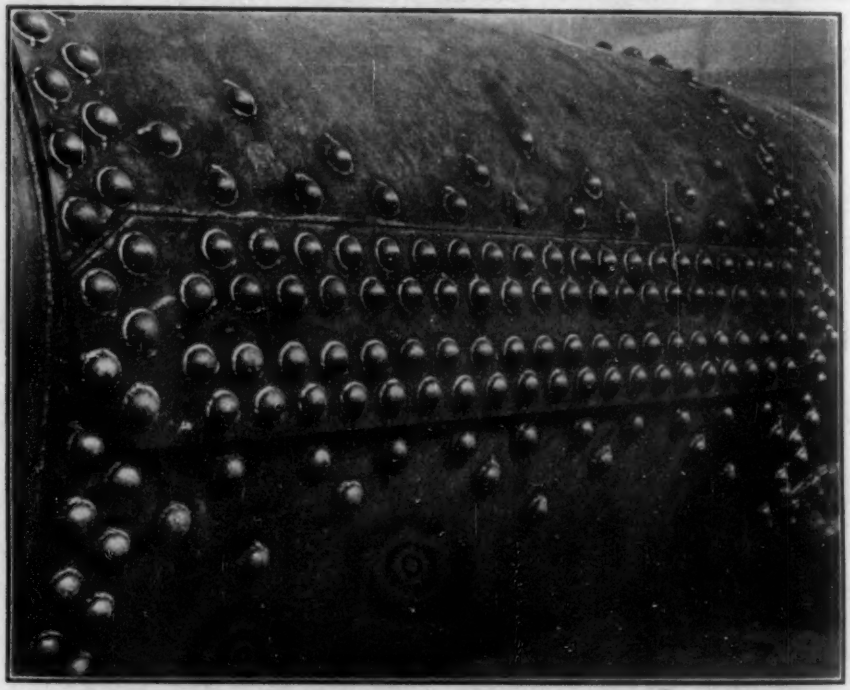

Fig. 3—Caulk welding of seams and rivets inside and out on riveted pressure drums

perience such as to give them a fair knowledge of the physical working of metals. Neat, conscientious work, with the thought of quantity, but never at the sacrifice of quality, should give unquestionable results, if properly handled in training.

Too little time is given to the training of new welders. The training period throughout the different industrial shops ranges from one week to six months. This varies with the different shops throughout the country and is governed somewhat by the pressure of work under way.

Welders, as compared with boilermakers, machinists, and other mechanical labor, should be on a standard equal to the highest. As has already been stated, there is no other trade in which the results depend so largely upon the individual as in welding. The welder's

responsibilities are affected by a wide range of conditions, and the art should receive a high standard of recognition when compared with the other mechanical trades. This alone will be manifested in the results that will be obtained through more conscientious work.

It must be assumed that the foreman in charge is capable to the extent of affording proper supervision of all work. He must have a thorough knowledge of the material to be welded if his results are to be satisfactory. The success of any weld depends largely upon whether the material has been properly prepared and whether the most adaptable process, for the service, has been employed. For this reason, the foreman should be fully acquainted with the working conditions to which the weld is to be subjected, and the

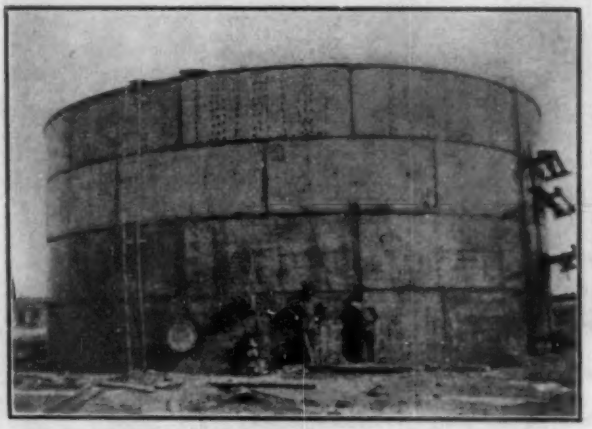

Fig. 4—Oil storage tank built by the welding process

suitability of the different types of welding and design of welds for these conditions. The question of whether studding, preheating, and the many other points to be taken into consideration in the proper preparation of a weld, has been intelligently considered, is of primary importance.

A weld in which all possible precautions may have been taken up to the time of being finished, may yet prove unsatisfactory unless properly treated before being placed in service. Particular care should be taken to avoid having any cold strains in the metal. This is especially true of metals subjected to high temperatures and pressures. Due to the nature of the service, the character and type of weld, it is quite necessary that certain welds be annealed if we hope to obtain the best results in service.

The necessity of annealing welds has raised some discussion by some of the different shops. However, knowing as we do that the resulting metal in a weld, no matter how made, is nothing more than cast steel and the resulting effect of annealing upon this type of ferrous metal, there should be no question as to the desirability

of annealing welds. This is accomplished by two methods, called complete and partial annealing. The former covers the annealing of the entire piece of work after being finished, by placing it in an annealing furnace and allowing it to soak at a temperature around 1600 deg. Fahr., after which it is allowed to cool slowly. Partial annealing often applies to welding in which the entire piece of work is too large to be placed in an annealing furnace. This is accomplished by localized heating of the weld and the adjoining metal by torches. In all cases, it should be appreciated that the annealing temperature of the deposited metal is higher than that of the virgin metal if the best results are to be obtained. If the annealing is properly carried out, the weld will be more ductile, possess better

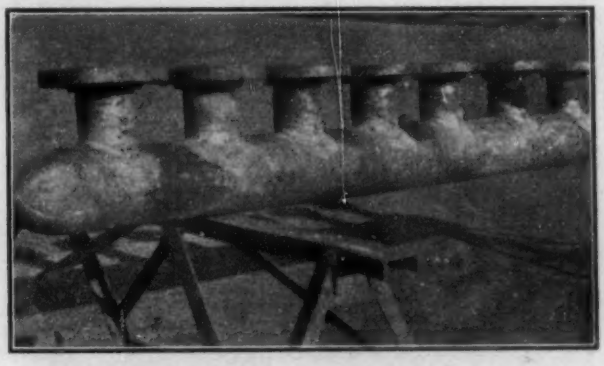

Fig. 5—Welded manifold from six inch extra heavy pipe

machining qualities, have a finer grain structure, and be free of strains.

As previously mentioned, welding in some form or other can be found in practically every branch of the oil industry; and, despite its many uncertainties with which it is attributed, its use is rapidly gaining favor. Its demand and use is far ahead of its research advice as to its practical application.

There are many things which the oil man must consider in selecting the type of welding to be used. That is, shall he use gas, electric, resistance, thermit, or forge welding. In the refineries, where welding is finding a great field of usefulness, the points that are usually considered are: The adaptability to give the best results, and the resulting cost. This rule cannot always be followed in the refineries and much less in the fields, particularly in foreign production. It may be found while the cheapest process if properly done, would be entirely satisfactory, that due to the lack of facilities, one of the more expensive processes, is the cheaper, when considering the initial investment necessary. For instance, it has been found more economical in certain fields to weld sections of heating coils by the thermit process than by either the gas or electric processes. This was due to the amount of work being small and did not warrant an investment for gas or electric welding equip-

ment. This is equally true of where both gas and electric welding could be used. Due to the lack of electric welding apparatus and power facilities, gas welding is resorted to entirely rather than make the additional investment for apparatus. Wherever possible, however, the deciding factors should be the quality desired and the cost resulting.

Probably in refining equipment is where welding has obtained its greatest stronghold. Due to changes in processes and design, welding in this field alone has great possibilities. While both gas and electric are used, the demand for the latter has grown so until its volume now is about two to one when compared with gas. While these two processes are by far the most used at present, thermit welding is gradually cutting into the volume of work and should soon be equally in demand on pipe and coil work.

In taking up the different applications, the welding of storage tanks and other similarly constructed equipment probably presents the largest field for increasing the volume of welding. The magnitude of this phase of welding alone has already been brought out in papers read before this Society.

It has been conservatively figured by some oil companies that their average annual loss in stored products is five (5) per cent. This loss may be analyzed as consisting of the evaporation through the roof and roof vents, as effected by breathing, resulting from temperature changes, and the loss through leaks and seepage at the riveted joints, with subsequent evaporation. The loss of light products, while not as noticeable as the heavier oils, is much greater and in a few years will equal the value of the tank.

The industry, through years of research, has developed the various refining processes in order to obtain greater yields of light products from the crude, but only within recent years have they taken steps to prevent the evaporation of these light products while in storage. This subject is receiving considerable attention at present and one of the means being employed is welded tank roofs and bottoms. The welding of roofs and bottoms of storage tanks up to 115 ft. x 40 ft. size, by the electric process, is becoming a common practice in tank building. Gas welding for this work is not only more expensive but presents greater erection difficulties. Very little difficulty has been experienced in the welding of the roofs and bottoms, but the complete welding of a tank of this size presents quite a problem to the majority of tank builders. Aside from the trouble of holding the sheets in place and other erection difficulties, the weather condition must be more favorable than for riveted tank work. Smaller size tanks, however, have been completely welded and are giving satisfactory service today. Once the proper standards and designs are arrived at, the welded tank should be cheaper to build than the riveted constructed tank. However, the large saving to be effected will result in the elimination of seepage and evaporation of the lighter hydrocarbons and reduced cost in upkeep.

With the present riveted type of construction and on those al-

ready erected, there is the possibility of using a small fillet weld along the riveted joint in the shell in place of pneumatic caulking. This would eliminate any possible chance of leaks at the joints and should afford ideal work for a small portable automatic welding tool.

This Society had a committee, upon which the writer had the privilege of serving, to work out detailed plans and specifications for the welding of oil storage tanks. With all due respect to the committee and the results which it obtained, there was no one on the committee who was familiar with the practical end of building storage tanks by the welded process, and yet, at the same time, this very thing was being done. The committee made its report, based largely upon assumptions and laboratory tests, and has since become inactive. The writer believes that this committee, or a similar one, should not remain inactive if this problem, which is a big one, is going to be put across and made a success by this Society.

The pneumatic caulking of pressure distilling and cracking equipment is rapidly being replaced by electric welding. The drums, which vary from $\frac{7}{8}$ in. up to $2\frac{1}{2}$ in. in shell thickness, are largely of riveted construction. In some instances, these drums are forge welded and are known as seamless drums. However, as a result of going to the higher temperatures and pressures, which has resulted in the use of heavier plates, riveted construction has been largely resorted to. The seams are electrically caulk welded inside and out. This not only makes the joint tight but prevents coke getting underneath the plates and butt-straps. This also prevents corrosion from occurring along the caulking edge, all of which would make further caulking difficult. In some installations, due to the high temperatures and pressures, at which the equipment operates, the rivets are also caulk-welded inside and out, so as to eliminate all possible chance of leaks. This practice has also resulted in large savings in repairs in the case of non-pressure drums subjected to fire, in preventing the lap of the riveted joint in the bottom sheet from buckling.

In some drums recently built, the caulk welding of the joints, rivets, manheads, and all other connections to the shells, amounted to between 1000 ft. and 1200 ft. of single strip weld per drum. The welds measured about $\frac{5}{8}$ in. across the face and were applied at the rate of $2\frac{1}{2}$ to 3 ft. per hour. Aside from the welding on the shells, a large amount of the structural work for supporting the interior of these units was welded. The interior heating and condensing coils, which are all made from seamless tubing, are welded by several different processes, namely, gas, resistance, butt, and resistance lap hammered, and thermit.

The welding of cold and hot oil lines by the acetylene method is becoming a common practice. While gas is used more extensively at present, the practice tends to indicate that thermit and electric welding will soon be in equal demand for this class of work. This type of construction is being advocated and in some instances is

being used under high temperature and pressure conditions. The welded joint, if properly made, will not leak and will be stronger than the screwed connection. Welded manifolds around pump houses and transfer stations are especially desirable, as it is very difficult to make these manifolds up from screwed fittings so as to be tight when handling the lighter products. This practice has also been resorted to in cases where it was impossible to get delivery of fittings, which resulted in a large saving in time and money.

The welding of screwed fittings and flanges in oil lines is being done as an extra precaution against leaks and the possible stripping of the threads due to expansion and contraction in the line. Steam lines and headers up to 16 in. in diameter are being acetylene welded with satisfactory results.

Aside from that already mentioned, there is a large amount of miscellaneous welding being done by the refineries. This includes such work as structural work, repairs to tanks and boilers, laboratory and experimental equipment, building up of parts that have worn or corroded away, and the salvaging of castings. It has been found that the welding of steel castings, which have a tendency to be porous, is very difficult and after once done, the castings are hardly ever tight. Localized defects, however, such as blow holes, gas pockets, etc., can be satisfactorily repaired by welding. As a result of changes in the process of refining and the going to higher temperatures and pressures, cast iron is being rapidly replaced by cast steel and, as a result, the amount of welding of cast iron, outside of repair work, is small.

In the sales departments, which take care of the marketing of the finished products, welding is being applied to the station storage tanks. In some instances, these tanks are forge welded drums taken from refinery equipment which has been replaced or since become obsolete. The truck tanks are welded as well as the steel drums in which large shipments are made. The curb pumps and the underground storage tanks used in this phase of the industry are electric welded. Repairs are constantly being made by both the gas and electric processes.

Welding has only been used within recent years, to any degree, by the producing and pipe line interests, particularly the latter. The satisfaction that has been obtained from welding in these two fields has resulted in a much broader use of the art and a rapid increase in the volume of work.

The initial pressure of the wells in some fields is very high, when first brought in. These pressures fluctuate and any defects in the caps result in considerable loss and damage. Gas welded caps are being used in some fields satisfactorily on pressures between 1500 to 1600 lb. The construction of these caps by welding is both simplified and cheapened. The oil, when it first comes out of the ground, carries with it a large amount of gas, which is removed by

passing the oil through traps. These traps are welded, which is advocated as being a reliable method of construction.

The gas production of the fields contains a large percentage of gasoline, which is removed by gasoline plants of either the absorption or compression type. Not only the cooling coils, but the drums as well, are welded, which make the construction much cheaper than if made from screwed fittings.

While gas welding is considered as standard construction in laying gas transportation lines, it has only been during the last few years that this type of construction has been applied to oil transportation lines. Within the past few years, there have been several lines laid by the pipe line companies. These lines are six and eight inches and range from 100 to 150 miles in length. Regular steel line pipe was used, the joints being single V Butt. The results to date have shown that the welded lines are not only about 25 per cent cheaper to lay than coupled lines, but that no trouble has been experienced with leaky joints, which usually results in damage suits. The experience of some transportation companies with welded lines has been such that they feel that line walkers are not necessary on such lines.

Practically all of the welded lines laid to date, both gas and oil, have been gas welded. Welding of pipe lines by the thermit process does present great possibilities and undoubtedly will, in a few years, be equally as popular for pipe line work. To date, however, no lines of any size have been laid.

Repairs to coupled lines are made, the new joints being welded. The building of manifolds from steel line pipe and cast or forged steel flanges is becoming a common practice in pipe line manifold work around pumping and transfer stations. The salvaging of pipe and the welding of used pipe into frame work for portable pump and tool houses and manifold stations is now being done.

There is a large amount of equipment purchased by the industry from reputable concerns wherein welding has been employed in some form of other. Refrigerating equipment, condensers, heaters, coils, valves, and fittings are a few of the many commodities purchased in which welding is applicable.

This summary, which has consisted largely of generalities, gives you some idea of the extensive use of welding, in its different forms, in the oil industry. While the volume of work already being done may seem large, the field in the oil industry is of such magnitude that that which is now being done will only be a small percentage of that in a few years hence. Furthering the application of welding to the oil industry, as well as to any other industry, can be brought about by greater research advice based upon practical experience as well as laboratory knowledge along the lines of design, quality and costs, recommendations as to the uses of the different types of welding purely from a standpoint of satisfaction and cost, and a closer cooperation of all interested in the art purely with the thought of its advancement and not for commercial reasons.

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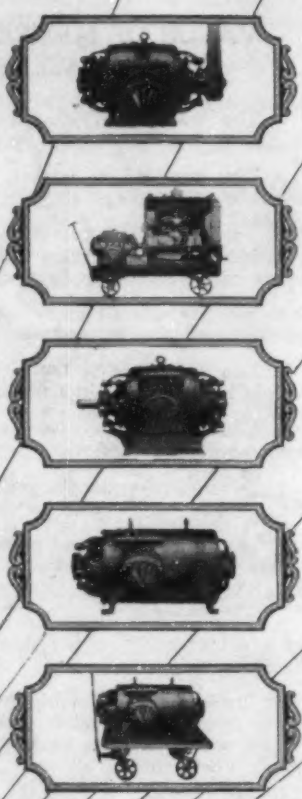

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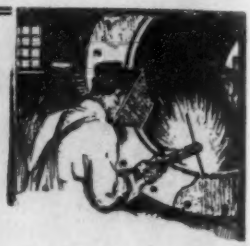

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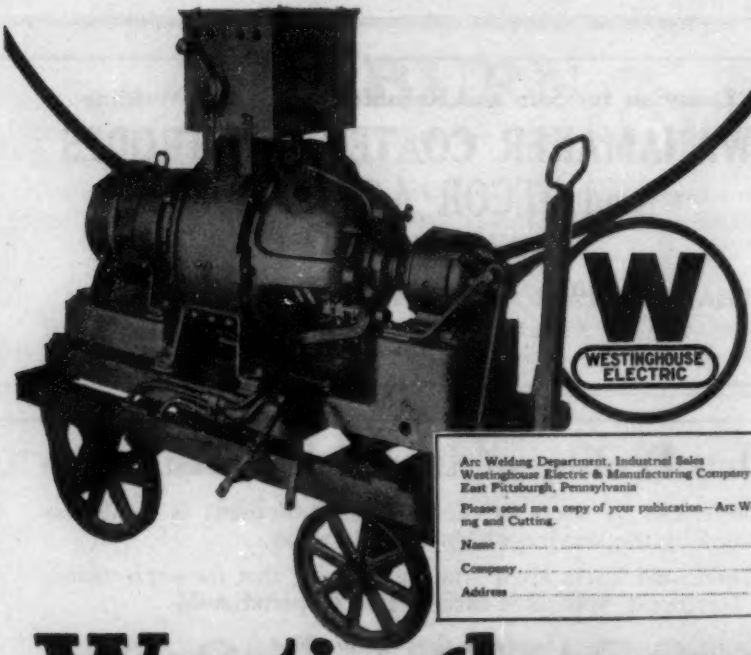

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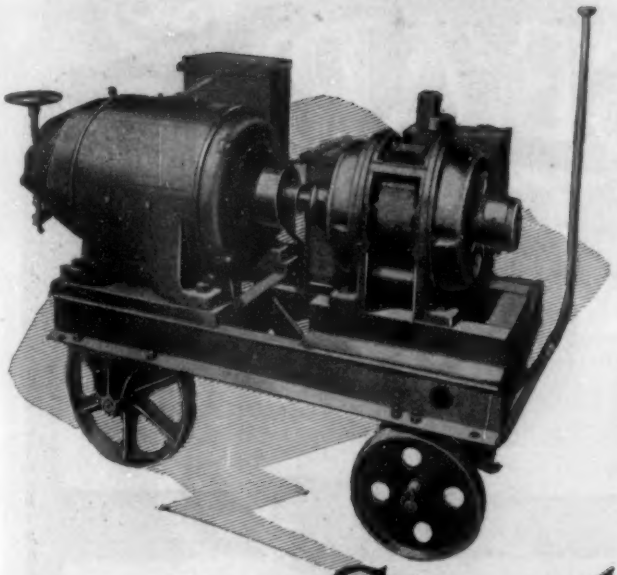

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